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Ringing Applied to the Commercial Orchard

J. H. Gourley and F. S. Howlett

OHIO
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SUMMARY

The experiments herein reported were designed to determine the value of ringing as a commercial practice, the aim being to bring about fruit production of filler trees that are tardy in reaching the age of bearing. The experiments reported, together with preliminary trials, have extended over a period of five years.

The ringing was applied more particularly to those varieties that have the reputation of being slow in reaching the age of profitable production. The varieties included in the major part of the work were Baldwin and Liveland Raspberry; altho a number of others were also treated, such as Stayman Winesap, which, however, is not often a tardy bearer.

It was found that scoring, that is the drawing of a knife blade around a limb so as to sever all the tissues of the bark or bast, gives as satisfactory a response as the removal of a ring of bark and makes a less objectionable wound. The binding of a limb or trunk with wire did not accomplish the purpose of ringing.

It is very desirable to protect the wound produced in ringing, with a waxed tape, or a substitute for it, in order to reduce water loss from the exposed tissues and to protect them from the entrance of microorganisms.

The scoring or ringing should be done the latter part of May or early June in the general region of northern Ohio. The chief objects are to cut the tissue at a time when the wound will heal rapidly and prior to the time of fruit bud differentiation.

While the entire trunk of the tree may be successfully scored or ringed, it seems desirable to treat only one or two major limbs at a time. This obviates the necessity of treating the same parts two years in succession and is less likely to injure the tree.

There was a reduction of leaf surface of the treated limbs the season following the operation. This was due to a partial failure of the lateral buds to develop.

There was no difference between the color of the foliage or time of leaf fall of the leaves on the ringed and unringed limbs of vigorous trees.

In these experiments, following abundant flower formation on the ringed limbs, there was usually a definite reduction in the average area of the leaves on the non-flowering terminal shoots. It

appeared that this reduction was little, if any, more than results normally when a limb produces flowers freely and sets a crop of fruit.

No significant difference was found between the average length of the non-flowering terminal shoots of the ringed and unringed portions of the same tree. However, due to terminal flowering, the total shoot growth was less on the ringed than on the unringed portions.

Either scoring or ringing resulted in a high percentage of fruit-bud formation with most varieties, as shown by the blossoming the following spring. Not only were fruit buds formed terminally on spurs and long and short shoots, but also quite freely as lateral or axillary buds.

Trees in a vigorous condition, developed a normal set of fruit. The size, flavor, and keeping quality of such fruit was not affected by the practice.

Since these experiments have demonstrated that tardy bearing apple trees can be brought into fruiting by ringing or scoring without serious injury, the practice is recommended for the special conditions described.

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INTRODUCTION

The removal of a ring of bark or some other means of temporarily interfering with the movement of materials in the bark or bast has frequently been employed with several of the fruit plants to bring about the formation of flower buds. The removal of a ring of bark is often called "ringing". This procedure is also useful in the study of some of the physiological processes of plants, but in the present study the object was to determine its application to the commercial apple orchard and to learn the least objectionable wound that would accomplish the purpose.

Several cultural methods may be used to hasten the bearing of an orchard. But certain varieties are slow in reaching the age of profitable production and do not readily respond to the usual methods of culture. This delay occasionally becomes so serious that requests are made for a special practice that will force such trees into earlier bearing. Particularly is this true of filler trees that, by some error or circumstance, are late instead of early producing varieties.

In all cases with the apple, the need for ringing should be temporary only, for every means should be employed to bring about bearing by good culture rather than by relying on such an extreme practice. Nevertheless, there are occasional conditions in Ohio where ringing is justifiable and where material returns can be secured without injury to the trees. It is important, however, to distinguish such cases and then use the greatest care in the practice.

SOME CAUSES OF UNFRUITFULNESS

Causes of unfruitfulness have frequently been suggested in horticultural literature and it is not necessary to discuss them at length. It should be made clear, however, that a distinction must be made between non-flowering and non-fruiting of trees. Ringing has not been suggested as a relief for trees that blossom and fail to set fruit, but only for those of sufficient age that fail to form fruit buds.

Variety.—While the individual tree, or even a branch, may be the unit of consideration, yet a survey of reports from orchards shows that failure to form fruit buds is largely a varietal problem. Rarely is a serious complaint made that Grimes Golden, Jonathan, King David, Oldenburg, or Winter Banana, for instance, is unfruitful; but Baldwin, Delicious, Esopus Spitzenburg, Northern Spy, and Liveland Raspberry are frequently reported. It is, therefore, with the tardy bearers as a general group that a study of ringing is largely concerned.

Age and size of tree.—It seems obvious enough that a tree must attain a certain size and age before fruit production is to be expected. But just how big and how old? The experienced orchardist is likely to base his decision on his experience with other varieties, but appreciating that a little variation is to be expected. After a reasonable time has elapsed and good culture fails to bring his trees to fruition, he then turns to drastic measures such as ringing.

Fig. 1.—Flowering of Stayman Winesap due to a label wire at X

A variety that is somewhat tardy in reaching full production, say 12 or 13 years from time of setting, may be sufficiently valuable to warrant the waiting, but when such a variety is planted as a filler tree, then the delay may render its total productive period unprofitable. A filler tree should be at least five or six years old and be making an average terminal growth of at least 12 to 15 inches before ringing is used.

Hence we conclude that the size and age that a standard tree has attained are two of the factors that should be considered in determining whether or not it is unfruitful.

Nutrition.—Another common reason why trees are unproductive or fail to reach bearing age as soon as might be expected is their nutritional condition. For instance, Stayman Winesap trees that would normally come into commercial bearing at about 8 years of age when favorable cultural conditions are maintained, may not be in bearing when they are 13 or 14 years of age or older, if the soil

is infertile and proper nutrients or other essential factors are not supplied. It would be unfortunate to ring under those conditions, rather than to cultivate the land, use nitrogenous fertilizers, or otherwise supply the lack whatever it is. Occasionally there may be trees or orchards that fail to come into bearing because of conditions that are so favorable to growth extension that fruit bud differentiation fails, but such conditions are not common in the State.

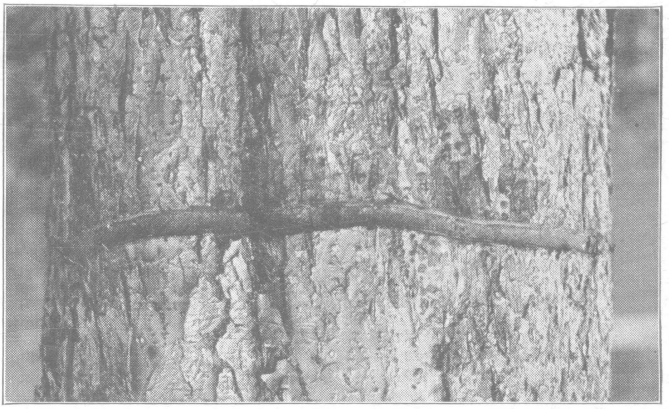

Fig. 2.—A 35-year-old Baldwin that was ringed on the trunk and is healing perfectly

Other factors that influence nutritional condition of the tree, such as excessive or deficient pruning, unfavorable moisture relations in the soil, or shading, are sometimes involved, but are not discussed in this connection.

PHYSIOLOGICAL EFFECT OF RINGING

Ringing is generally considered to interrupt the downward passage of substances elaborated by the leaves. When the ringing consists in the removal of a narrow ring of bark or in scoring, the interruption is only temporary. No matter how soon the wound heals the interruption is sufficient to cause the accumulation of carbohydrate and other leaf-formed materials in the parts above the ring. Fruit-bud formation appears either to be caused by or accompanied by such accumulation of carbohydrate. From the experimental evidence now available it appears that the change in total nitrogen content brought about by ringing within a fairly wide range is not a factor of importance in the formation of fruit buds.

THE RINGING OPERATION

The immediate object to be attained in the ringing operation is to secure a temporary cessation in the downward translocation of plant food without permanent injury to the tree. This object may be attained in several ways and no one way has been entirely established as superior to all others. Among those that have been observed are: cutting out a ring of bark, twisting a wire tightly about the branch or trunk, drawing a sharp blade around the limb or trunk without removing a section of bark (called "scoring" in this paper), and such accidental injuries as killing of bark by fire or disease, or by knawing of rodents.

CUTTING OUT A RING OF BARK

Cutting out a ring of bark is the most common method and is the one that is usually meant by the term "ringing". It refers to the cutting out, or peeling off, of a ring of bark, varying from a thin slice up to an inch or even more in width. It is accomplished by making two parallel cuts around the limb or trunk either with an ordinary knife or an instrument prepared for the purpose. In the work here reported the usual width of the ring was a quarter of an inch or less. (Fig. 3). After the cuts were made the ring of bark was peeled off so that the exposed cambial tissue was not scratched or injured by scraping. The proper time for this work is the latter part of May or early part of June in the region of Wooster. However, there are no narrow limits, provided the cuts are made before fruit bud differentiation has taken place, and at a time when growth is active so that the wound will heal readily.

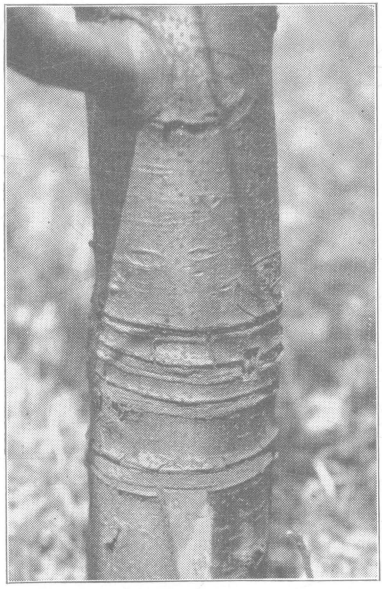

Fig. 3.—A Stayman Winesap that was ringed on the trunk four years in succession, with a definite response each year and without serious depression of tree growth.

After the ring of bark has been removed it is desirable to cover the wound to reduce the likelihood of permanent injury from either infection or desiccation. A suitable material is cotton cloth torn in

strips and wrapped in loose balls and placed in hot grafting wax until the material is impregnated with the wax. This tape is stiff and will not draw into the wound as the untreated cloth will. This is important. Waxed tape will adhere to the bark and when overlapped does not need a tack to hold it in place. Tire tape or any other substitute meeting these requirements is satisfactory. In this work it was not found necessary to disinfect the wound with an antiseptic solution.

When protected in this way the wound will heal rapidly. If the cambial cells are uninjured they will immediately produce a uniform layer of new cells over the exposed area. This tissue gradually replaces the ring of bark and by the end of the growing season it apparently functions as before the treatment. If, however, the cambial cells are dried or injured the healing takes place in another way. The callous-like growth appears at the edges of the wound where the severed bark and the wood cylinder are united. These callous tissues grow rapidly and unite from above and below and usually soon fill the wound, even protruding considerably above the level of the bark, especially if the tape is not removed. Occasionally this tender tissue is attacked by colonies of the woolly aphis.

Fig. 4.—Tree at right foreground in Baldwin orchard ringed April 28. It was necessary to bridge graft the wound as growth had not yet started. Used by courtesy of N. H. Exp. Sta.

If the wound is not protected the healing is almost always by means of the callous and frequently the wound is not completely healed the first season. Furthermore, if the tree is weak from any cause, the healing may be greatly retarded and injury result.

It is of interest to note in this connection that in an orchard where ringing was applied as a test of its adaptability to commercial culture, the wounds healed in a satisfactory way as indicated by the following letter: "You will be interested to know that in all the ringing we have done in the two seasons (approximately on 12,000 trees), we have not lost a ringed limb or apparently injured a tree permanently. We did have one small area where the grafting wax covering material was pulled into the wound in 1925 and delayed the healing process and caused the affected limbs to ripen early in the fall. A profusion of water sprouts was thrown out just below the ring. At pruning time we left these on and then grafted them into the limbs above the ring when conditions were right (in May, 1926). The area could not be located in the orchard in 1926."* Figure 5.

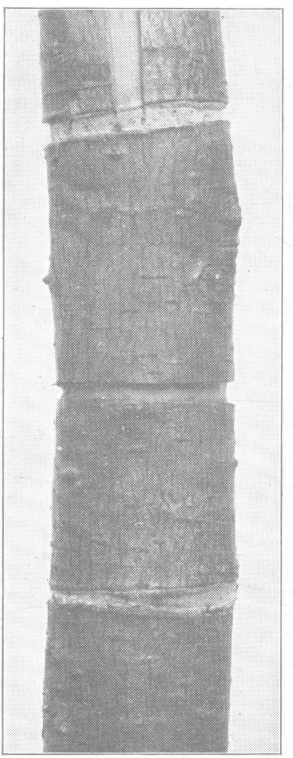

Fig. 5.—Type of callus formation when ringing is carefully done during period of active growth. Ringed above and below 16 days before photograph was taken. Center ring made at time of photographing.

WIRING OR BANDING THE TREES

It has sometimes been suggested that there would be less injury and equally good results if wires were drawn tightly about the limbs or trunk so that the tissue in growing would be constricted by the wire, bringing about the same condition as by cutting.

Wiring was not practiced as extensively as ringing, but comparisons were made at three orchards in the State and certain conclusions drawn from them. Baling wire was used because it is pliable and of suitable gauge to manipulate easily. Sometime in April it was fitted closely about the trunk or limb and twisted as tightly as possible without breaking, tapping it during the tightening so that it would fit into any irregularity. By the middle of August enough growth had taken place to leave the wire embedded flush with the outer surface of the bark and it was then removed.

These observations were made with Liveland Raspberry, Stayman Winesap, Esopus Spitzenburg, Stark, Rome Beauty, Jonathan,

*Letter of Mr. Howard Ingerson (Bingham Orchard Co.), Chardon, O., Feb. 18, 1927.

Sutton Beauty, Grimes Golden, and Baldwin, 30 trees in all, some of which had several limbs wired instead of the trunk. No flowering whatever occurred with Stayman Winesap, Baldwin, and Liveland Raspberry. The flowering of the other varieties was no greater than with the untreated trees. (Table 5). When a label wire is left on a limb it may become so embedded in the bark as to cut thru to the wood. This seems to be equivalent to cutting by any other means and usually has the same effect. The results, however, are quite variable and entirely unreliable as a practice. The only conclusion that can be drawn from these experiments is that wiring as here practiced failed as a substitute for some means of severing the tissue to bring about fruit-bud formation. (Fig. 6.)

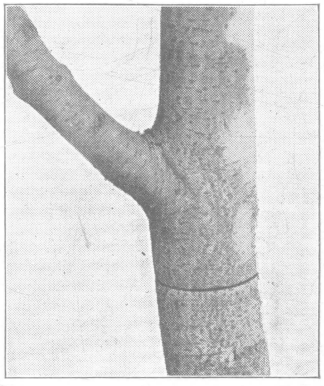

Fig. 6.—Showing the bark constriction due to a wire girdle left there from April until August 1. No blossoming resulted.

SCORING

Objection may be raised to the exposure of internal tissue of a tree, such as is necessary in the usual ringing operation, because of the large wound that must be healed, of the possible entrance of blight or other disease, and of the difficulty in making a neat wound. Because of these objections (none of which was ever serious in our own work extending over ten years), a partial substitute, termed *scoring*, is proposed. As described before, it consists in drawing the knife blade about the limb, being particular to sever all the tissue in to the wood but without removing any bark. In some cases two such scores were made about an inch apart, to make sure of a complete temporary cessation of the passage of materials thru the bark. As a matter of insurance the use of two scores in orchard practice is recommended. In this way a less objectionable wound is made and the results are satisfactory. (Fig. 7). While there is less need of protecting such a wound, waxed tape was used as a precautionary measure and is advisable in all cases.

RINGING PORTION OF TREE ONLY

Reference has been made to the treatment of one or more major limbs instead of the entire trunk of a tree. This seems to be desirable from several standpoints. Should injury occur the trunk of the tree will escape and only certain branches will be affected.

Furthermore, the entire root system is not affected by the treatment. There was no evidence of serious injury to the roots even tho the entire tree were ringed, but there may be a certain amount of checking or repression of root development. From a practical standpoint, it is an advantage to have several untreated limbs on the tree that can be operated on the following season and even the third season, if the tree has not yet come into bearing by the cultural treatments employed. Ringing the same limb in consecutive years is not recommended. At least a year should intervene.

Fig. 7.—Limb to left ringed four years in succession. Limb to right scored only.

EFFECT OF SOIL TREATMENT AT TIME OF RINGING

The question may be raised as to whether a stimulation of the tree by the use of quickly available nitrogenous fertilizers previous to, at, or shortly after the time of ringing, will have any depressing effect upon fruit-bud formation. That is, will there be any tendency to nullify the usual response of the tree to the ringing operation by a stimulation of vegetative extension rather than the production of flowering parts, or will both responses occur? In the light of usual orchard experience this question is scarcely warranted but data on this point can be cited from these experiments, as follows:

TABLE 1.—Effect of Soil Treatment Upon Response to Ringing

All trees ringed, Waterville, Ohio, 1924

Treatment per tree	Percentage of bloom (estimated)
Average 10 trees—no fertilizer	75
Average 10 trees—3 lb. sulfate ammonia (April)	79
Average 10 trees—1½ lb. sulfate ammonia (April) + 2 lb. nitrate soda (June)	74
Average 5 trees—4 lb. sulfate ammonia (April) + 8 lb. acid phosphate + 3 lb. muriate potash	80

It can be clearly seen from these data that both the fertilized and unfertilized trees in this ringed block responded much the same and the amount of chemicals used in no way offset the stimulus of ringing.

In the Bingham orchards, Chardon, Ohio, where much of the work here reported was conducted, the trees were cultivated and fertilized with 1½ pounds of sulfate of ammonia two to three weeks previous to the normal time of blossoming. No depressing effect of fruit-bud formation was experienced.

EFFECT OF PRUNING ON THE RESPONSE TO RINGING

No comparative tests with the effect of different kinds, amounts, or time of pruning upon the response to the ringing operation were made in these experiments. However, it may be stated that dormant pruning of both old and young trees was practiced thruout and there was no depressing effect upon fruit-bud formation. Sufficient unpruned trees were available to determine this point.

EFFECT OF RINGING UPON GROWTH

The data are primarily concerned with the effect of ringing upon the subsequent growth and vigor of one or more scaffold limbs of a tree rather than the effect upon entirely ringed trees. The number, size, and color of the leaves as well as the length of the non-flowering terminal shoots of the ringed limbs were compared with the corresponding indices of vigor on the unringed portion of the same tree.

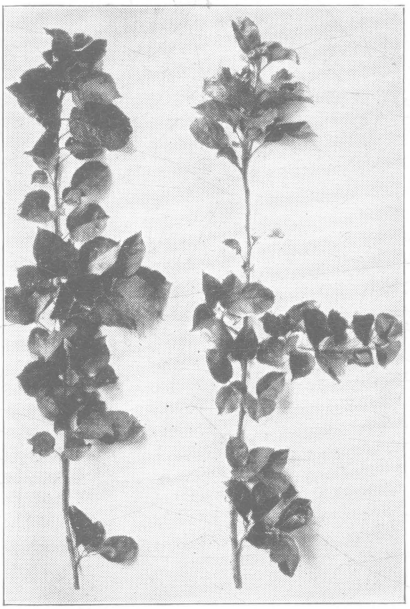

Fig. 8.—Branches of Liveland raspberry showing areas where leaves fail to develop on ringed portion.
Left—Branch from unringed limb
Right—Branch from ringed limb

NUMBER OF LEAVES

In these experiments the foliage on the ringed limbs the year following the ringing was somewhat sparse, which agrees with Drinkard's (2) observations of ringed trees. This indicates that

there was a smaller number of leaves on the ringed limbs than on unringed limbs of the same size. The leaves on the current terminal shoots of the ringed limbs appeared to be as numerous as those on the unringed limbs. The sparseness of the foliage was due, as indicated in Figure 8 to the failure of a large proportion of the buds on the shoot growth the year of ringing to develop. Not only the greater number of the buds along the median but also along the apical region of the shoots remained dormant. The leaves of the buds which did break were not of uniform size. It has been observed, however, that the lateral buds on the previous season's growth of unringed flowering and fruiting trees also occasionally remain dormant (Fig. 8).

COLOR OF LEAVES

The foliage on the ringed limbs of trees that were of good vigor previous to the ringing was dark green and vigorous, not only during the season of ringing but also thruout the subsequent, or fruiting, year. The leaves on the ringed limbs neither turned yellow nor dropped prematurely the year of ringing, as they sometimes do after ringing, if the wounds fail to heal.

SIZE OF LEAVES

Collections of leaves were made on July 27, 1923, from the non-flowering terminal shoots of limbs and trees of Stayman Winesap ringed the latter part of May, 1922 and 1923. The fifth to ninth leaves from the basal end of the 1923 growth were chosen. The trees were planted in 1916 and were growing in sod without nitrogen fertilization. They were of moderate vigor. The ringed limbs bloomed abundantly following the ringing. The data are given in Table 2. The average leaf area of the limbs and tree ringed in 1922 was significantly smaller than that of the unringed limbs and tree.

On July 14, 1925, leaves were taken from a similar position on the current season's terminal shoots of ringed and unringed limbs of three of the same Stayman Winesap trees. The bloom was fairly satisfactory. The data given in Table 2 indicate that the differences between the average leaf area of the ringed and unringed limbs were hardly significant.

In like manner leaves were also collected from Liveland Raspberry. The trees were of moderate vigor. The ringed limbs had bloomed satisfactorily, but a heavy frost, 4 weeks after full bloom, limited the set to relatively few fruits. The ringed trees bloomed abundantly. The data are also presented in Table 2. The differences between the mean leaf area of the ringed and unringed

branches of trees 1, 2, and 4 were not significant. On tree 3 the leaves on the ringed branch were significantly smaller. The mean leaf area of the ringed tree was also smaller than that of the unringed trees.

From these experiments it appeared that when flowers were formed abundantly on the ringed limb, there usually followed during the year of flowering a definite reduction in mean area of leaves on the non-flowering terminal shoots. This reduction was little if any more than results normally when a limb produces flowers freely and sets a crop of fruit.

TABLE 2.—Effect of Ringing Upon Mean Area of Leaves From Ringed Limb, Wooster

Tree No	Condition of limb*	Number of leaves measured	Mean leaf area (sq. in.)	Difference in favor of unringed limb(+) ringed limb(—)
	Stayman Winesap, measured July 27, 1923			
1	Ringed 1922	50	3.9±.08	+1.2±.11
	Ringed 1923	50	4.8±.09	+0.3±.11
	Unringed	100	5.1±.07	
2	Ringed 1922	50	3.3±.09	+1.7±.12
	Ringed 1922 and 1923	50	3.2±.08	+1.8±.11
	Unringed	100	5.0±.08	
3	Ringed 1922 and 1923	50	3.3±.09	+1.5±.13
	Unringed	100	4.8±.09	
4	Whole tree ringed 1922 and 1923	100	3.3±.06	+1.5±.08
5	Tree unringed	100	4.8±.06	
	Stayman Winesap, measured July 14, 1925			
1	Ringed 1924	50	5.2±.11	+0.4±.15
	Ringed 1925	74	5.8±.09	—0.2±.14
	Unringed	69	5.6±.10	
2	Ringed 1923 and 1924	75	5.2±.10	+0.3±.12
	Unringed	99	5.5±.07	
3	Ringed 1923, 1924, 1925	50	5.0±.10	—0.4±.13
	Ringed 1925	50	4.2±.08	+0.4±.11
	Unringed	75	4.6±.08	
	Liveland Raspberry, measured July 14, 1925			
1	Ringed 1924	100	6.4±.09	+0.3±.12
	Unringed	100	6.7±.08	
2	Ringed 1924	50	6.1±.13	—0.3±.18
	Unringed	50	5.8±.13	
3	Ringed 1924	100	5.2±.09	+0.5±.13
	Unringed	95	5.7±.09	
4	Ringed 1924	100	5.6±.09	.0±.13
	Unringed	98	5.6±.09	
5	Whole tree ringed	247	4.3±.05	
6	Tree unringed	176	5.1±.08	+0.8±.09
7	Tree unringed	91	5.5±.08	+1.2±.10

*Ringing was done late in May each year.

TERMINAL SHOOT GROWTH

In the extensive orchards of Dr. C. A. Bingham, at Chardon, where there were 12,000 filler trees of the Baldwin variety that were vigorous but unproductive, opportunity was extended the writers to apply ringing on a large scale. These trees were ten years old in 1924 when the work was begun. At that time 100 trees were taken at different places in the orchards and a portion of each tree ringed.

TABLE 3.—Relation of Length Growth of Non-Flowering Terminal Shoots of Ringed Limb to Length of Terminal Shoots of Unringed Limbs. Baldwin. Chardon, 1925

Ringed June 16-17, 1924. Measured October 7, 1925

Tree No.	Average length of non-flowering terminal shoots (inches)				Difference in favor of unringed limb (+) ringed limb (—)*	
	1924		1925			
	Ringed limb	Unringed limb	Ringed limb	Unringed limb	1924	1925
1	11.7±0.88	16.0±0.47	8.4±0.22	9.0±0.15	+4.3±1.00	+0.6±0.26
2	16.3±0.26	16.3±0.32	7.5±0.17	7.9±0.30	0.0±0.41	+0.4±0.35
3	7.9±0.79	16.0±0.32	9.4±0.46	9.6±0.22	+8.1±0.85	+0.2±0.52
4	20.6±1.24	16.5±1.00	10.6±0.07	9.0±0.28	—4.1±1.59	—1.6±0.29
5	16.4±0.43	16.4±1.00	8.0±0.66	9.5±0.25	0.0±1.09	+1.5±0.71
6	16.7±0.52	17.1±0.66	9.8±1.18	10.2±0.88	+0.4±0.84	+0.4±1.47
7	16.6±0.56	17.0±0.60	9.2±0.30	8.6±0.21	+0.4±0.82	—0.6±0.36
8	11.8±0.37	14.8±1.05	6.3±0.53	8.5±0.88	+3.0±1.11	+2.2±1.03
9	19.7±0.87	17.2±0.37	10.9±0.23	8.7±0.18	—2.5±0.95	—2.2±0.29
10	13.6±0.69	16.0±0.44	7.6±0.31	8.2±0.20	+2.4±0.82	+0.6±0.37
11	16.4±0.45	18.5±0.41	9.8±0.37	8.8±0.10	+2.1±0.61	—1.0±0.38
12	15.5±0.43	16.6±0.47	7.7±0.26	9.0±0.33	+1.1±0.64	+1.3±0.42
13	15.9±0.19	16.0±0.32	7.2±0.20	9.0±0.34	+0.1±0.37	+1.8±0.39
14	18.5±0.28	18.4±0.40	10.0±0.13	9.0±0.35	—0.1±0.49	—1.0±0.37
15	19.1±0.50	17.8±0.33	10.4±0.49	11.3±0.70	—1.3±0.60	+0.9±0.85
16	17.9±0.43	19.5±0.47	8.7±0.24	9.6±0.37	+1.6±0.64	+0.9±0.44
17	18.0±0.34	18.5±0.31	9.3±0.29	8.6±0.50	+0.5±0.46	—0.7±0.58
18	18.7±0.35	18.5±0.37	9.6±0.23	10.0±0.44	—0.2±0.51	—0.4±0.50
19	17.4±0.63	21.5±0.66	9.2±0.40	10.3±0.46	+4.1±0.91	+1.1±0.61
20	23.7±0.72	18.1±0.59	9.9±0.36	8.8±0.32	—5.6±0.93	—1.1±0.48
21	16.6±0.52	16.6±0.40	8.8±0.42	8.3±0.22	0.0±0.66	—0.5±0.48
22	20.3±1.34	17.3±0.31	9.3±0.25	9.8±0.30	—3.0±1.38	+0.5±0.39
23	20.4±0.63	18.6±0.35	9.6±0.40	9.3±0.40	—1.8±0.72	—0.3±0.57
24	22.6±1.48	15.6±1.49	9.6±0.40	9.3±0.13	—7.0±2.10	—0.3±0.42
Av.	17.2	17.4	9.0	9.2	.....	.....

*Errors in Probable Errors found in Tables II and III of article, "Has Ringing any Place in Commercial Orchard Practice?" Proc. Amer. Soc. Hort. Sci., 1925 (22):22-28, 1926, corrected in this table.

Measurements were made in October 1925 of the 1924 and 1925 length growth of non-flowering terminal shoots of the ringed limbs. The number of measurements on these limbs was necessarily limited, usually ten to fifteen, because of the large number of terminal flower clusters, formed as a result of the ringing. The length of terminal shoots on the unringed limbs of the same trees was taken for comparison. The data are given in Table 3. In 1924, on only 4 of the 24 trees (1, 3, 11, and 19) was the average terminal

shoot length significantly greater on the unringed than on the ringed limbs. On two trees (20 and 24) the differences were in favor of the ringed limbs. In 1925, the year of flowering, on two trees (12 and 13) the average shoot length of the unringed limbs was greater than the ringed. On two trees (4 and 9) the reverse was true. On all others the differences were not significant.

TABLE 4.—Relation of Length Growth of Non-Flowering Terminal Shoots of Ringed Limbs to Length of Terminal Shoots of Unringed Limbs. Liveland Raspberry. Wooster

Ringed May 20, 1924. Measured September 19, 1925

Tree No.	Average length of non-flowering terminal shoots (inches) 1925		Difference in favor of unringed limb (+) ringed limb (−)
	Ringed limb	Unringed limb	
1	6.4±.23	5.9±.25	−0.5±.34
2	6.7±.17	7.4±.28	+0.7±.36
3	6.8±.32	7.8±.33	+1.0±.46
		Unringed trees	
4		6.1±.19	
5	Ringed trees	6.4±.20	
		Av. 6.3±.20	
6	7.2±.41		−0.9±.46
7	7.9±.24		−1.6±.31

In like manner measurements were made in September 1925 of the 1925 length growth of Liveland Raspberry. The trees were growing in the same orchard as those whose average leaf area is given in Table 2. The ringed limbs had a moderate and the ringed trees a heavy bloom. The data are given in Table 4. The difference between the ringed and unringed limbs on the same trees was not significant. However, on one ringed tree (7) the relatively few non-flowering terminal shoots were longer than the average of the unringed trees.

The data as a whole showed no consistent differences between the average length growth of the non-flowering terminal shoots of the ringed and unringed portions of the same trees either during the year of ringing or the subsequent fruiting year. It is probable that following very heavy flowering the non-flowering terminal shoots on ringed limbs may occasionally be shorter.

The fact that the number of non-flowering terminal shoots is limited on ringed limbs indicates that such measurements were not a true index of the total growth of the ringed and unringed limbs.

The total shoot growth was greater on the unringed limbs. However, the data suggest that no serious injury occurred to the ringed limbs as a result of ringing.

TOTAL TOP GROWTH

Ringing usually results in dwarfing the top as indicated by Alderman and Auchter (1). However, this dwarfing is to a considerable degree caused by, and is in proportion to, the heavy flowering and fruiting produced. In these experiments the ringing when confined to the main scaffold limbs did not cause greater dwarfing than frequently results on unringed trees from heavy flowering and fruiting. However, reduced leaf surface in the ringed portions would have some effect in retarding the total growth of the tree over and above that caused by flower and fruit production.

No such unfavorable results from ringing as reported by Howe (5) and Fagan (4) were ever obtained by the authors. Howe obtained very harmful effects, including death of trees, and no fruit bud formation from ringing immature Baldwin trees (3 and 4 years from planting) with rings 1 to 20 inches in width. The rings were unnecessarily wide and Baldwin trees of that age and immaturity could hardly be expected to give satisfactory results. Moreover, the wounds were not protected from drying out. However, Drinkard (3) reported in cases in which a ring of bark one-fourth to one-half inch wide had been removed from the trunk of a tree, that the growth of the trees was good. He concluded that complete healing may be expected when the work is properly done and the wounds protected.

ROOT GROWTH

No data are available from this study to indicate the relative growth of the roots of the ringed and unringed portions. Probably ringing reduced the root growth by obstructing the movement of essential substances to the roots. When an entire tree is ringed, the root growth is probably reduced. When large branches are ringed, the reduction is largely confined to the feeding roots of the ringed branches.

EFFECT OF RINGING UPON BLOOMING AND YIELD

Here, of course, is the crux of the whole matter, for the sole purpose of ringing or scoring is to bring about sufficient fruit-bud formation to produce a commercial crop. If only a few scattering fruits result, the practice must be considered a failure from the

standpoint of the orchardist. Or, if a weakness of the tree accompanies ringing so that the fruit does not develop normally, or a future impairment results, then it must be eliminated from consideration. But the foregoing discussion of the effect upon growth together with the favorable results upon fruit production warrant the conclusion that ringing is a legitimate and safe practice for vigorous but unproductive filler trees that have reached sufficient maturity.

THE FARNSWORTH ORCHARDS

In the orchards of the W. W. Farnsworth Company, Waterville, considerable ringing has been done and opportunity was extended to make observations of the results. The trees were 17 years old at the time of ringing, 1923. They had been cultivated, manured, and fertilized during the life of the orchard and were in a good state of vigor, but were slow in coming into heavy commercial bearing. Only the filler trees were ringed, and the work was done with a saw. It so happened, however, that all the trees in the orchard blossomed the spring following the treatment so that the results were not striking, as would ordinarily be the case. Considering all varieties, the bloom on the ringed trees was estimated as 75 and on the unringed 43 percent. The wired trees gave no significant results, as shown in Table 5.

TABLE 5.—Ringing and Wiring in Farnsworth Orchard, 1924

Percentage of Bloom

Variety	Unringed	Ringed	Wired
Baldwin	0	15.4	0
Duchess	41.0	.....	18.0
Grimes Golden	49.8	86.8	73.7
Jonathan	28.0	76.2	33.3
McIntosh	83.0	85.1	72.5
Northern Spy	.....	1.0	0
Rome Beauty	61.4	93.8	61.2
Sutton Beauty	.3	10.0	0
Yellow Transparent	36.9	.....	25.5

Here it will be seen that the varieties responded somewhat differently to ringing and that Northern Spy gave no response. In such a year it was of little or no avail to have ringed the trees, but the previous history of the orchard justified the attempt to bring these filler trees into full bearing by this method.

It seems to be characteristic of Northern Spy, Sutton Beauty, and Liveland Raspberry that they make a feebler response to ringing than many other varieties. From the evidence secured in this

work it seems that varieties fall into certain categories in regard to their response to ringing; some very responsive, others moderately so, and still others making little or no response.

THE BINGHAM ORCHARDS

As indicated in the discussion of growth, the most extensive work in the series of experiments was in the Bingham orchards near Chardon. The Baldwin, a variety ill adapted to the purpose, had been planted extensively for a filler. Since the trees were in a good state of vigor, as indicated by their growth and the color of the foliage, as well as sufficiently mature for fruit production, ringing and scoring were applied for an extensive test of the practice. An estimate at harvest time showed that one-fourth to one-fifth of each tree had been ringed.

Striking results were seen at blossom time in 1925. There were ample blossoms on the ringed limbs for a good set of fruit, but practically no blossoms on the rest of the tree. Unfortunately, a heavy frost during blossom season injured the blossoms to a serious extent. However a sufficient number escaped for a set of fruit and a little more than a bushel of apples of excellent size and color was harvested per tree (Table 6). Some trees had two or three bushels each.

TABLE 6.—Yield of Ringed Limbs of Baldwin, Chardon, 1925

Ringed June 17, 1924

Row	Trees in row	Percentage of tree ringed	Yield of ringed limbs per tree
	No.	*Pct.*	*Bu.*
31	14	23.6	1.20
32	17	21.2	1.12
79	13	22.1	1.59
100*	56	26.1	0.57

*The trees in this were smaller and made a feebler response.

This success resulted in a further test, and 12,000 Baldwins and 1,000 each of Delicious, Northern Spy, and Bellflower were ringed by the owner in 1925. In 1926, 103 Baldwin trees were selected as a representative sample for study (Table 7). On the trees of this group no blossoms occurred except on the ringed limbs. A few of the other trees produced some fruit on the unringed portions, but not enough to consider the trees as a group in bearing. The average percentage of tree treated was increased in 1925 to about 56 percent. The fruit set well and was very heavily thinned in order

TABLE 7.—Yield of Ringed Limbs of Baldwin, Chardon, 1926

Ringed May, 1925

Row	Trees in row	Percentage of tree ringed	Yield of ringed limbs per tree
	No.	*Pct.*	*Bu.*
15	33	53	2.55
20	24	54	2.44
25	20	62	3.25
30	26	58	2.89
Average	103	56	2.75

to conserve the trees and avoid breakage. The yields varied from occasionally only a slight response up to 8 bushels, with an average yield per tree of 2.75 bushels (Fig. 9).

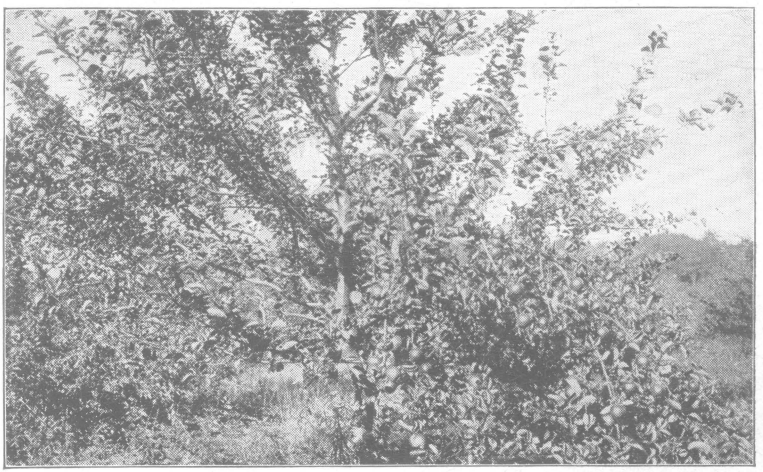

Fig. 9.—Baldwin. Bearing Limb (to right) was ringed

COST OF RINGING

The cost of ringing includes the labor, the original cost and breakage of the knives, and the cost of materials used to cover the wound areas. Scoring can be done much quicker than ringing, thus reducing materially the labor cost.

The cost of ringing on a large commercial scale is indicated by the approximate cost of the practice in the Bingham Orchards in 1925 and 1926 as given in Table 8.

In 1926 the wound areas on scored trees were not covered, which partially accounts for the difference in cost. In that year

four high school boys and a foreman each scored 35 to 40 trees per hour.

When ringing is done on a smaller scale, the cost per tree will be increased.

TABLE 8.—Cost of Ringing in Bingham Orchards, Chardon, Ohio

1925 and 1926

	1925	1926
Trees involved, number	10,000	15,000
Percentage of top ringed, percent	60	56
Total labor cost, dollars	266	116
Total material cost, dollars	75*	4
Cost per 1000 trees, dollars	34.10	7.73
Cost per tree, cents	3.4	0.8

*Largely for grafting wax and muslin for wrapping.

APPLICATION OF RINGING TO THE ORCHARD

The conclusions of horticulturists in general have been that ringing results in such a serious check of the tree growth as to be injurious and, therefore, not to be recommended as an orchard practice. Investigators have recognized that flowering and fruit production will result the season after the operation is performed, but they have felt that the orchardist will be ahead in the long run if he waits until the trees come into bearing without this drastic means of forcing them. This conclusion seems justified from the cases cited and remains unchallenged as a promiscuous orchard practice for all non-bearing trees. Thruout this paper the reader has been cautioned against the improper use of ringing as well as encouraged in its proper use under certain limited conditions.

As already suggested the principal use of ringing is with filler apple trees. The value of filler trees is sometimes questioned even under favorable conditions, but certainly they are quite likely to prove unprofitable when late producing varieties, such as Baldwin, Esopus Spitzenburg, Liveland Raspberry, and some others are used. Such varieties are not often planted intentionally as fillers, but not infrequently, thru error, the orchardist is faced with the problem of securing early cropping from such late producing sorts. In a large orchard the loss due to delayed fruiting may be great. One to three bushels of apples per tree where none would have been produced otherwise will do much toward making the purpose of the filler trees realized. Particularly is this true when there is no injury of consequence, as in the work here reported.

There are conditions under which it is inadvisable to practice ringing or scoring and herein lies much of the danger in bringing the practice to public notice. Weak trees, that are standing in sod and unfertilized, or that are "undervegetative" from other causes, are not likely to respond to the treatment, are less likely to heal, and distinct injury or death may follow. Ringing is not designed for such cases. Neither should very young trees nor the smaller limbs on suitable trees be treated, largely because of the unfavorable response. To ring trees the year they are producing a heavy crop as a means of bringing about annual production seems unjustified. While not included in these experiments, it may be said that the stone fruits (peach, plum, and cherry) are not suitable subjects for ringing, because the wounds are not likely to heal satisfactorily in this climate, and the need is usually more rare.

In addition to the filler trees which are given prominence in this bulletin, there are other special cases where ringing may be followed. The Station practices it regularly in bringing about early production of seedling apples. This makes possible the early elimination of undesirable ones and hastens the work. Again, there are individual trees on the home grounds, as well as in the commercial orchard, where the practice would seem to be justified.

Finally, with the precautions to operate at the proper time of year, to make certain that the tissue is cut thru to the wood whether ringing or scoring, to treat one or two scaffold limbs only, to maintain a vigorous growth of tree partly to reduce likelihood of injury but particularly to bring the tree into production normally as soon as possible, and to thin the fruit if it sets heavy, the practice should serve a very useful purpose in the cases for which it is designed.

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